Introductory lesson:

--one plane only

SMART SKIES

Airspace Systems—Predicting Air Traffic Conflicts

Teacher Guide

Curriculum Supplement 0

Introducing Your Students to Airspace Systems

Overview of Curriculum Supplement 0

You may choose to spread the experiment and calculation activities over two or three class periods, allowing time for setting up the experiment, conducting the experiment, doing the calculations, and discussing the outcomes.

This unit introduces students to a series of eight Airspace Systems Curriculum Supplements that use distance, speed, and time relationships to predict air traffic conflicts. This Curriculum Supplement consists of an experiment, worksheets to support the experiment, and worksheets for paper-and-pencil calculations.

Each of the ensuing eight Curriculum Supplements examines a different air traffic scenario that an air traffic controller might encounter.

In Curriculum Supplements 1 through 6, the controller must track two airplanes on merging jet routes to avoid a conflict. Curriculum Supplements 7 and 8 address two airplanes on the same jet route, with the trailing airplane traveling faster than the leading airplane.

Objectives

The purpose of this Curriculum Supplement 0 is to prepare students for the two-plane scenarios by having them track the progress of just one plane.

Implementing the Activities

This introductory Curriculum Supplement consists of an experiment, several paper-and-pencil activities, and a CD-ROM about air traffic control.

Begin with the CD-ROM introduction to air traffic control (Activity 0.1). Continue with the classroom experiment (Activity 0.2). Finally, assign a paper-and-pencil calculation activity (Activity 0.3) to support the experiment.

After students have completed the experiment and at least one of the calculation worksheets, you may want to ask them to compare the results of the experiment with the results of their calculations.

Activity 0.0 --

Problem Statement

In a real-world scenario, the plane speed might be 400 nautical miles per hour. The plane might be 40 nautical miles from the point of intersection.

An international nautical mile is 1,852 meters.

A nautical mile per hour is called a "knot".

As a problem extension, you may want to ask your students to solve the problem using real-world data.

Student Handout:
Worksheet 0.0

Problem Statement
Worksheet 0.0 describes and illustrates the airplane scenario. The speed of the airplane is 1/2 foot/second. The airplane is 20 feet from the point of intersection.

Note: This speed and distance were chosen to reflect the classroom experiment that the students will conduct and are not related to real-world parameters.

One question is posed:

Q1: How many seconds will it take Flight WAL27 to travel 20 feet to the end of its route?

Materials
Worksheet 0.0: Problem Statement

Activity 0.1 --

CD-ROM

Estimated time:
30 minutes

See Air Traffic Controllers on the Job
The *Gate to Gate* CD-ROM (produced by NASA and the FAA) introduces students to the people who operate the federal air traffic control system and exposes students to the tools the controllers use.

The CD-ROM is divided into seven segments that correspond to the seven phases of an airplane journey from San Francisco to New York. To access a particular segment, click the corresponding airplane icon located on the circle on the *Gate to Gate* home screen.

If time is limited, you might direct your students to view only Segment 4 (En Route) and Segment 5 (Descent).

The CD-ROM viewing may be conducted as an individual, a small-group, or a whole-class activity.

Materials
Gate to Gate CD-ROM
PC or Mac

Activity 0.2 -- Experimentation

Estimated time:
Setup—30 minutes
Experiment—30 minutes

Student Handouts:
Worksheet 0.2A
Worksheet 0.2B
Worksheet 0.2C

You may want to give students an overview of the experiment including an explanation of what they will do in each activity.

You may want to ask your students to compare the experiment distances and speeds with the real-world speeds given in the sidenote for Activity 0.0.

You may want to ask your students to estimate the route layout before they measure.

Students who have little experience in measurement may benefit from first practicing skip counting (by 6) to prepare them to measure 6-inch lengths.

Classroom Experiment

In this small-group activity, students mark off the jet route on the classroom floor or on an outdoor area. Students assume the roles of pilots, air traffic controllers, and NASA scientists. The pilot steps down the jet route at a prescribed pace. The NASA scientists track and record the pilot's times and the corresponding distances from the end of the jet route. The air traffic controllers set the pace.

Materials

Activity 0.2A: Set Up the Experiment
--sidewalk chalk or masking tape
--measuring tape or ruler
--marking pens (optional)

Activity 0.2B: Conduct the Experiment
--1 stopwatch or 1 watch with a sweep second hand or 1 digital watch that indicates seconds
--pencils and Data Sheets (Worksheet 0.2C)
--signs identifying pilots, controllers, and NASA scientists
Note: the signs are available on the Smart Skies website.
--clipboard (optional)

Student Handouts:
--Worksheet 0.2A: Set Up the Experiment
--Worksheet 0.2B: Conduct the Experiment
--Worksheet 0.2C: Data Sheet

Worksheet 0.2A, Set Up the Experiment

If your classroom has 1-foot by 1-foot floor tiles, your students can use the tiles as guidelines for placing masking tape at 6-inch intervals along the jet route.

You may want to set up one jet route as a model that your students can copy.

After a group of students has completed its jet route set-up, you may find it helpful to have them compare their work with another student set-up.

Worksheet 0.2B, Conduct the Experiment

Assign students to positions on 4-5 person teams as follows:

--Lead Air Traffic Controller (1 student)

--Secondary Air Traffic Controller (1 student)
--Pilot (1 student)
--NASA Scientists (1 or 2 students)

It may be difficult for some student pilots to take 6-inch steps by placing one foot in front of the other. Instead, advise the pilots to place one foot on either side of the jet route and align their toes at each mark. It may be helpful for students to practice.

After the jet route is set up, have one group of students demonstrate the experiment while the rest of the class observes. Discuss and address any issues that may arise.

Perform the activity at least three times. Compare the results of each trial. Discuss the validity of the results.

Using experimentation (or calculation) students should determine that the plane will take 40 seconds to reach the end of the jet route.

Extensions:

1. Repeat the activity using different students as the Air Traffic Controllers, Pilots, and NASA Scientists.

2. Repeat the activity using jet routes longer than 20 feet. Increase the plane speed and the step size to 1 foot/second.

3. Have students draw a scale model of the experiment using real-world data. (See the sidenote for Activity 0.0).

Activity 0.3 -- Calculations

Estimated time:
15 - 30 minutes per worksheet

Calculate the Time to Reach the End of the Jet Route
This activity presents four different methods students can use to determine the number of seconds for a plane to arrive at the end of its jet route.

In Curriculum Supplements 1 through 8, students use the given distances and speeds to generate the data for the table and graphs. In this Curriculum Supplement, students are given almost all of the data. This enables them to concentrate on representing the data in tabular and graphical form.

The speed of the airplane is 1/2 foot/second and the airplane is 20 feet from the end of its jet route.

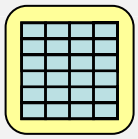
Using calculations (or experimentation) students should determine that the plane will take 40 seconds to reach the end of the jet route.

For a real-world speed and distance, see the sidenote for Activity 0.0.

Note: The speed and distance were chosen to reflect the classroom experiment that the students will conduct and are not related to

real-world parameters.

Student Handout:
Worksheet 0.3A



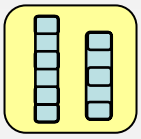
Worksheet 0.3A, Count Feet and Seconds—Students use patterns and skip-counting to complete a table and solve the problem.

At the end of this activity, students may realize it is faster to multiply than to add to obtain the answer.

Answer: The plane will take 40 seconds to reach the end of the jet route.

Prerequisite skills: count by 2s.

Student Handout:
Worksheet 0.3B



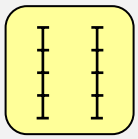
Worksheet 0.3B, Draw Blocks—Students draw blocks, each representing the distance the plane travels in 10 seconds. The students "stack" their blocks along a vertical number line that represents the jet route.

Notice that the vertical line is numbered from 20 at the bottom to 0 at the top. Students begin to stack the blocks at the starting point of the plane, 20 feet away from the intersection. The end of the route is represented with 0 at the top of the number line.

Answer: The plane will take 40 seconds to reach the end of the jet route.

Prerequisite skills: read and build a bar graph with a vertical scale marked in 1-foot units; count by 10s.

Student Handout:
Worksheet 0.3C



Worksheet 0.3C, Plot Points on a Vertical Line

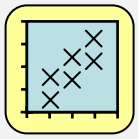
This graph is similar to the way families record and compare the height of their children at the same ages. They mark off each child's birthday height (distance from the floor) on a doorway and then record their age (time since birth) beside the height mark.

The students plot their points along a vertical number line that represents the jet route.

Notice that the vertical line is numbered from 20 at the bottom to 0 at the top. The bottom of the number line represents the starting point of the plane, 20 feet away from the end of the jet route. The end of the route is represented with 0 at the top of the number line.

Answer: The plane will take 40 seconds to reach the end of the jet

Student Handout:
Worksheet 0.3D



route.

Prerequisite skills: plot a point on a (vertical) number line.

Worksheet 0.3D, Plot Points on a Cartesian Coordinate System

Notice that the vertical axis is numbered from 0 at the top to **negative** 20 at the bottom. The numbers along the vertical axis represent the distance (with a negative sign attached) from the end of the jet route. Negative numbers are used because the points lie below the horizontal axis (the horizontal line at 0 feet).

Answer: The plane will take 40 seconds to reach the end of the jet route.

Prerequisite skills: plot a point on a Cartesian coordinate system (the xy-plane)

Extension (optional):
Connect the points with a straight line. Find the equation of the line.

Materials
Worksheet 0.3A: Calculate the time—count feet & seconds
Worksheet 0.3B: Calculate the time—draw blocks
Worksheet 0.3C: Calculate the time—plot on a vertical scale
Worksheet 0.3D: Calculate the time—plot points on a Cartesian coordinate system

_____
Name

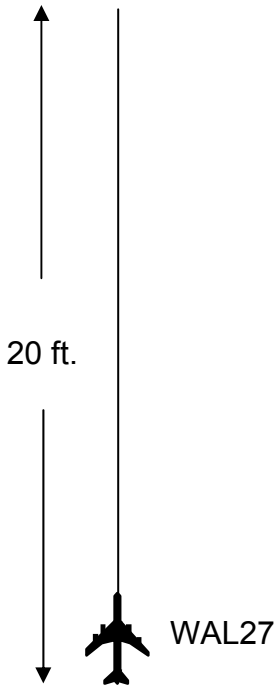
Problem Statement

The World Airlines plane has flight number **WAL**27.

The speed of Flight WAL27 is 1/2 foot/second (0.15 meters/second).

Flight WAL27 is 20 feet (6.1 meters) away from the end of its route.

Question: How many seconds will it take Flight WAL27 to travel 20 feet to the end of its route?



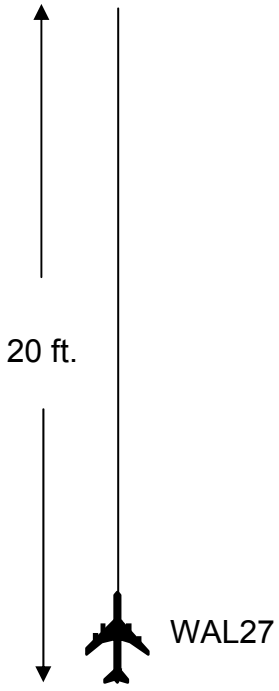
Name

Set Up the Experiment

1. Use sidewalk chalk (or masking tape) to lay out the jet route.
   The route should be 20 feet long.

2. The speed of Flight WAL27 is 1/2 foot/second.
   Stand at the beginning of the jet route.
   Place a mark (or a piece of masking tape) every 1/2 foot (every 6 inches) along the jet route. This will guide the pilot as he or she steps down the jet route.

3. On the jet route, place and label a longer chalk mark (or longer piece of masking tape) at the following positions:
   5 feet from the start, **10 feet** from the start, **15 feet** from the start, the **finish point**
   Note: The finish point is where the jet route ends.



Name

Conduct the Experiment

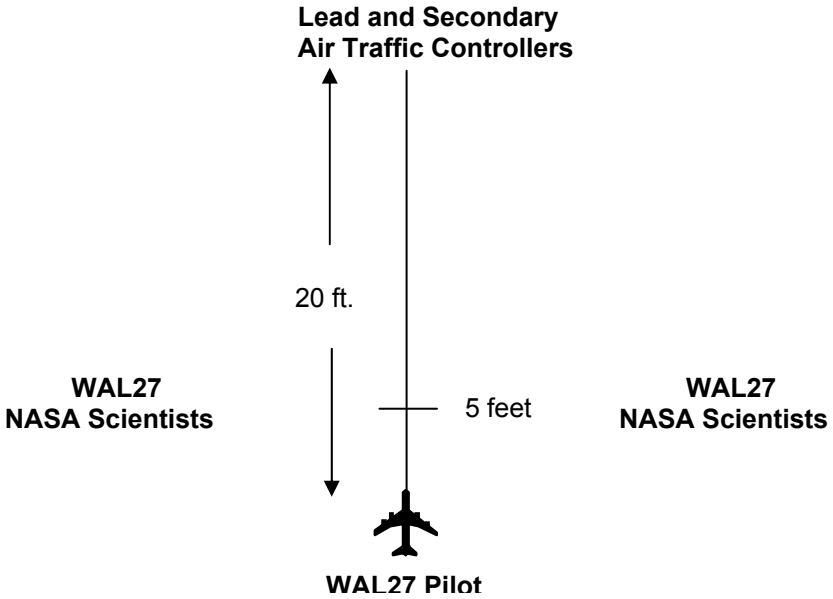
1. **Prepare for your part in the experiment.** Circle your role in the diagram and in the following list:

   Lead Air Traffic Controller: Stand at the end of the jet route. Make sure you can see the pilot when he or she arrives at the end of the jet route. Practice starting your stopwatch, counting the seconds aloud ("One, two, three…" and so on), and stopping your stopwatch.

   Secondary Controller: Stand at the end of the jet route. Make sure you can see the pilot when he or she arrives at the end of the jet route.

   Pilot: Position yourself at the start of the jet route. Then practice stepping down the jet route. Each step should be 1/2 foot. Since 1/2 foot is not a very big step, you may want to put one of your feet on each side of the jet route. Then slide your feet from one tape mark to the next.

   NASA Scientists: Stand on either side of the jet route at the 5-foot mark. As the pilot steps down the jet route, stay just ahead of the pilot and move to the 10-foot mark, the 15-foot mark, and the end of the jet route.



_____
Name

2. **Take your position.** Circle your role in the following list.

   Lead Air Traffic Controller: Give the command "Take your ready positions."
   Pilot: Position yourself at the start of the jet route.
   Secondary Controllers: Take your data sheet, measuring tape, and pencil and go to your controller location at the head of the jet route.
   NASA Scientists: Take your data sheet and pencil and go to your first observation position at the 5-foot line.

3. **Get ready to begin.** Circle your role in the following list:

   Lead Air Traffic Controller: Give the command "Set."
   Pilot: Prepare to step down the jet route.
   NASA Scientists: Get ready to measure and record the information on the data sheet.

4. **Begin the experiment.** Circle your role in the following list:

   Lead Air Traffic Controller: Give the command "Ready." Start your stopwatch and count the seconds aloud, "One, two, three…" and so on.
   Pilot: Take your first step on count "One." Each second, take one step to the next timing mark.
   NASA Scientists: Record the time the aircraft arrives at the 5-foot line. Stay ahead of the pilot and record the time the aircraft arrives at the 10-foot line, the 15-foot line, and the point where the Controller says, "Halt."

_____
Name

5. **End the experiment.** Circle your role in the following list:

   Secondary Controller: When the Pilot reaches the end of the jet route, give the command “Halt.”

   Lead Air Traffic Controller: Stop counting the seconds when you hear “Halt.”

   Pilot: Stop and remain where you are on the jet route when you hear “Halt.”

   NASA Scientists: Record the “Halt” time.

Name

Data Sheet

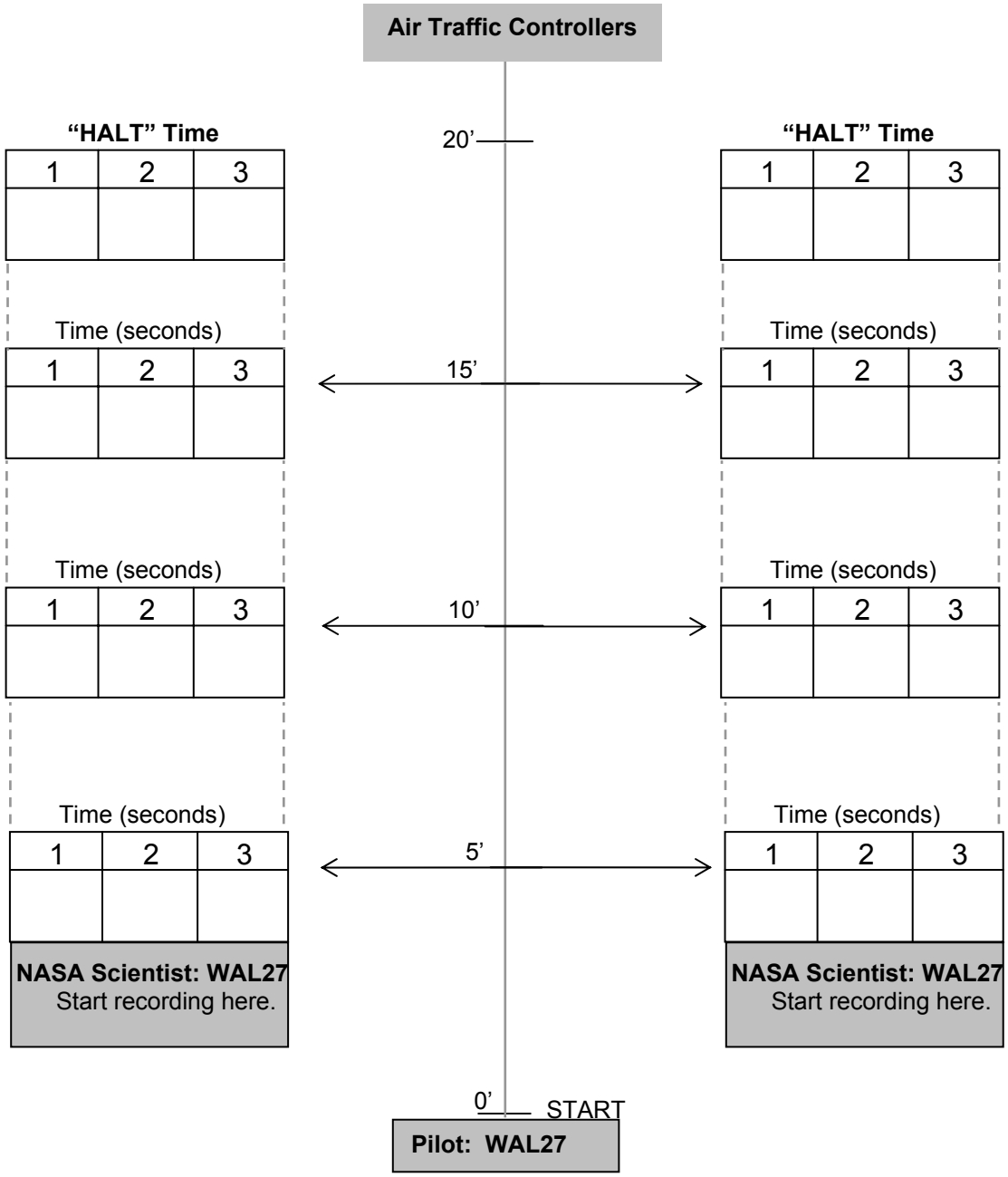
a. Fill in this table:

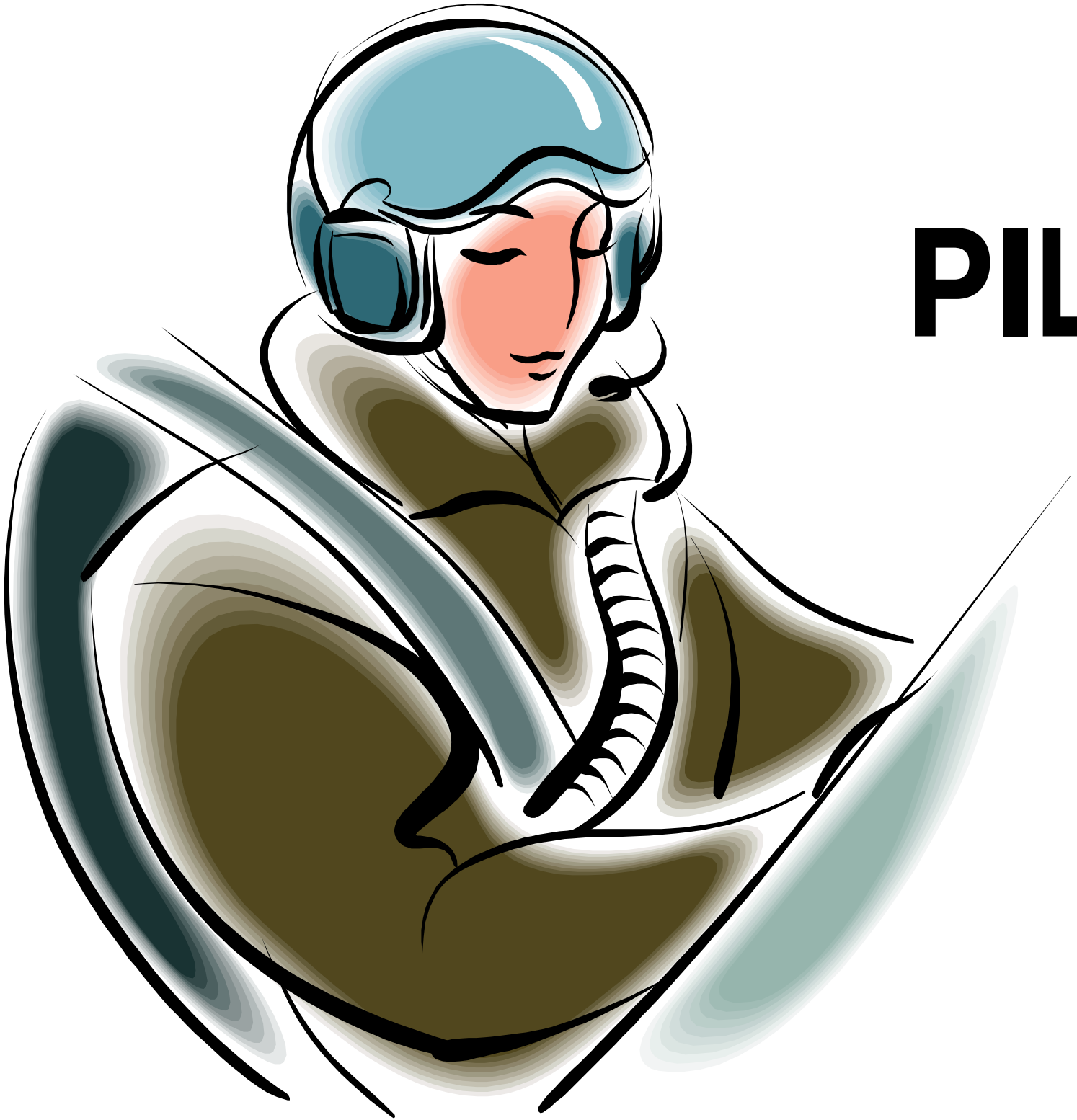
Flight Number	Speed	Distance from the Start of the Jet Route
WAL27		

b. On the picture below, circle your job title. Notice the data you need to record.

c. During Experiments 1, 2, and 3, record your data.

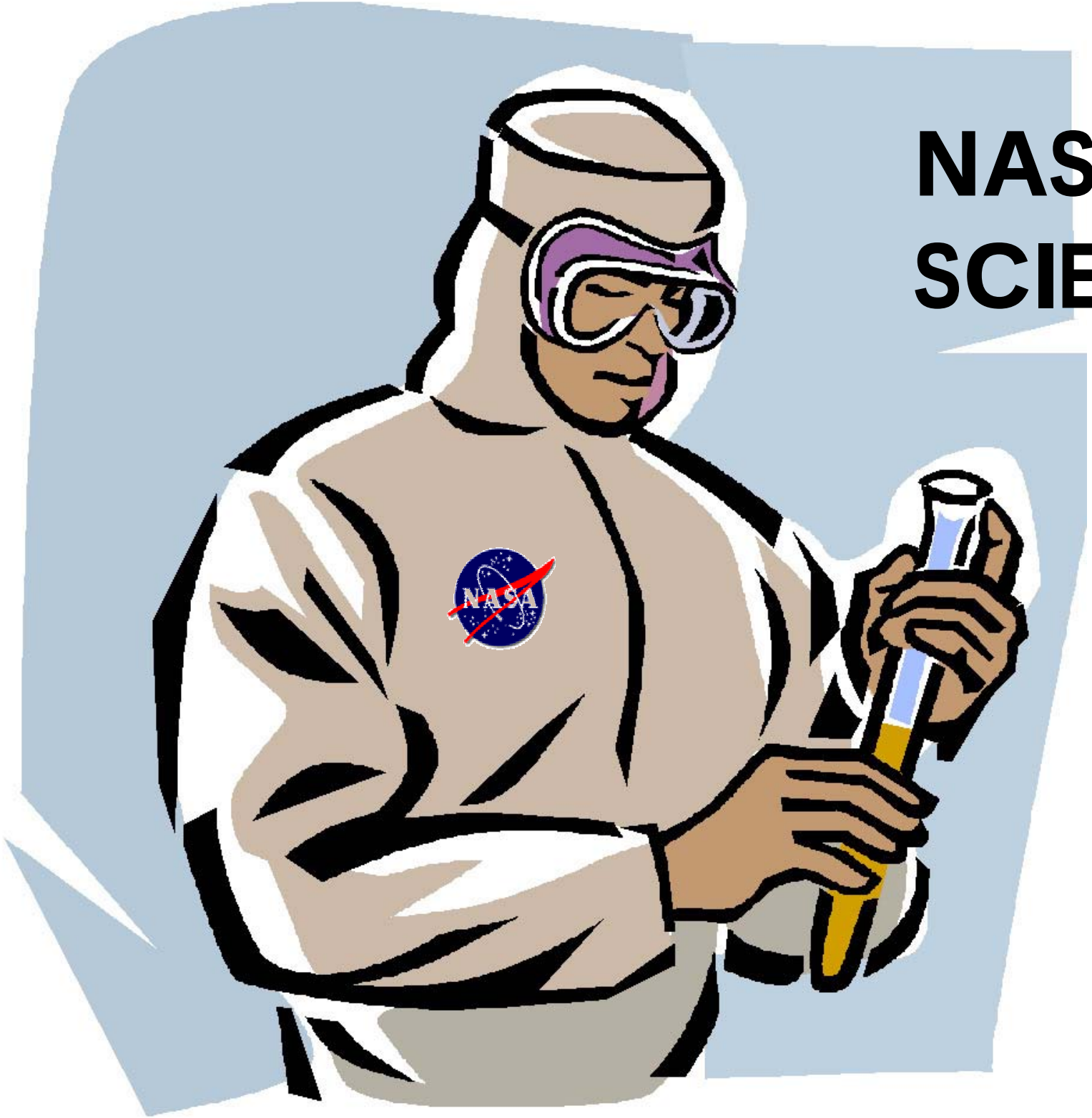
1	2	3





PILOT

AIR TRAFFIC CONTROLLER



NASA SCIENTIST

Name

How Much Time To Reach the End of the Jet Route?

(Count Feet and Seconds to Find the Answer)

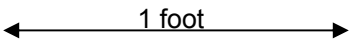
In the picture below, an airplane is flying on a jet route.

The World Airlines plane has flight number **WAL**27.

The speed of Flight WAL27 is 1/2 foot/second.

That means the airplane travels 1/2 foot in 1 second.

So the airplane travels 1 foot in 2 seconds.

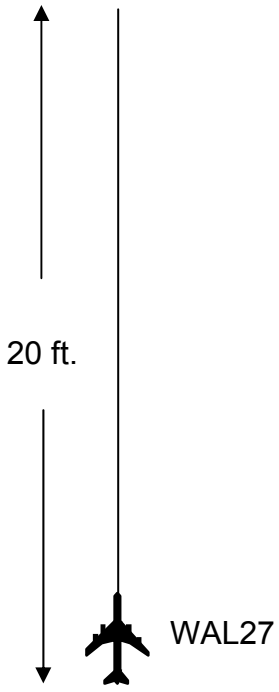


The airplane starts 20 feet from the end of its jet route.

1. Fill in the given table to see how many seconds it will take the plane to travel 20 feet.

After you fill in the table, answer the following question:

2. How many seconds will it take the plane to travel 20 feet and arrive at the end of the jet route? _____ seconds



Name

Flight WAL27	
How many feet?	How many seconds?
1	2
2	4
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Name

How Much Time To Reach the End of the Jet Route?

(Draw Blocks to Find the Answer)

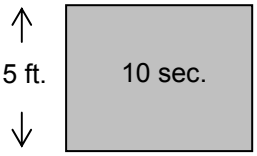
In the picture below, an airplane is flying on a jet route.

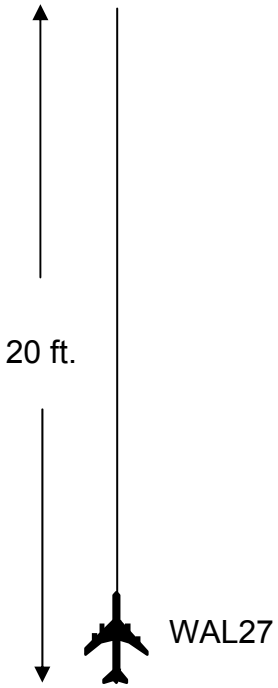
The World Airlines plane has flight number **WAL**27.

The speed of Flight WAL27 is 1/2 foot/second.
In 1 second, the airplane travels 1/2 foot.
In 2 seconds, the airplane travels 1 foot.

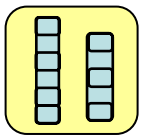
In 10 seconds (5 x 2 seconds), the plane travels 5 x 1 foot.
That is, the plane travels 5 feet in 10 seconds.

The height of this block represents 5 feet, the distance the plane travels in 10 seconds.





Name



Now you will use blocks to plot the position of the plane as it travels 20 feet to the end of the jet route.

Flight WAL27 started 20 feet away from the end of the jet route.
After 10 seconds, Flight WAL27 has moved 5 feet closer to the end of the route.
So the plane is 15 feet from the end of the jet route.

On the given diagram on page 3, a block shows the position of Flight WAL27 after 10 seconds.
An arrow points to the top of the block. The arrow is marked “10 seconds.”

Now it’s your turn to draw blocks on the given diagram.

- After 20 seconds, Flight WAL27 has moved 5 feet closer to the end of the jet route. So the plane is 10 feet from the end of the jet route.
- Trace the block that shows the position of Flight WAL27 after 20 seconds.
- At the top of the block, draw an arrow marked “20 seconds.”

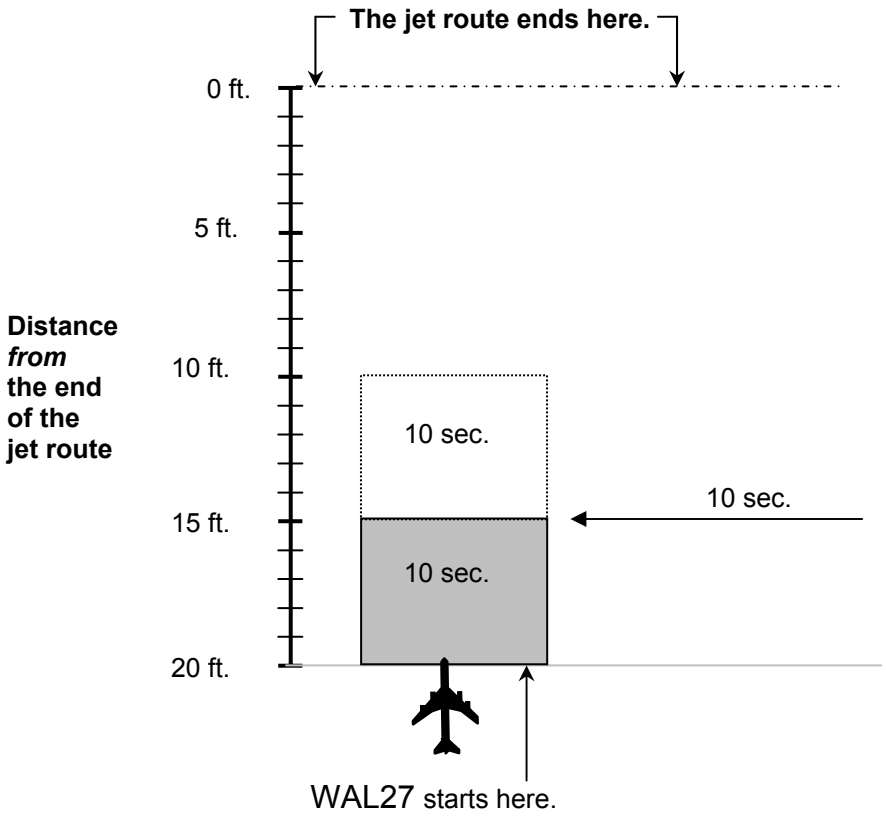
- After 30 seconds, Flight WAL27 has moved 5 feet closer to the end of the jet route. So the plane is 5 feet from the end of the jet route.
- Draw a block to show the position of Flight WAL27 after 30 seconds.
- At the top of the block, draw an arrow marked “30 seconds.”

- Keep going until the plane reaches the end of the jet route.

When you are done, answer this question.

How many seconds will it take Flight WAL27 to reach the end of its jet route? _____ seconds

Name


The jet route ends here.
0 ft.
5 ft.
10 ft.
15 ft.
20 ft.
Distance *from* the end of the jet route
10 sec.
10 sec.
10 sec.
WAL27 starts here.

Name

How Much Time To Reach the End of the Jet Route?

(Plot Points on a Line to Find the Answer)

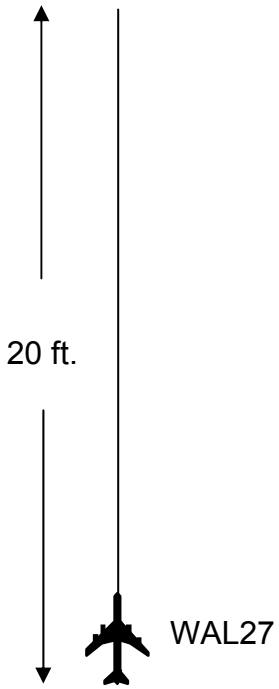
In the picture below, an airplane is flying on a jet route.

The World Airlines plane has flight number **WAL**27.

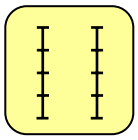
The speed of the airplane is 1/2 foot per second.

In 1 second, the airplane travels 1/2 foot.
In 2 seconds, the airplane travels 1 foot.

In 10 seconds (5 x 2 seconds), the plane travels 5 x 1 foot.
That is, the plane travels 5 feet in 10 seconds.



Name _____



Flight WAL27 started 20 feet from the end of the jet route.
After 10 seconds, Flight WAL27 has moved 5 feet closer to that point.
So the plane is 15 feet from the end of the jet route.

On the given diagram on page 3, an **X** shows the position of Flight WAL27 after 10 seconds.
An arrow points to the **X**. The arrow is marked "10 seconds."

Now, on the given diagram, you will use an **X** to plot the position of the plane as it travels 20 feet to the end of the jet route.

- □ After 20 seconds, Flight WAL27 has moved 5 feet closer to the end of the jet route. So the plane is 10 feet from the end of the jet route.
- □ Draw an **X** to show the position of Flight WAL27 after 20 seconds.
- □ At the **X**, draw an arrow marked "20 seconds."

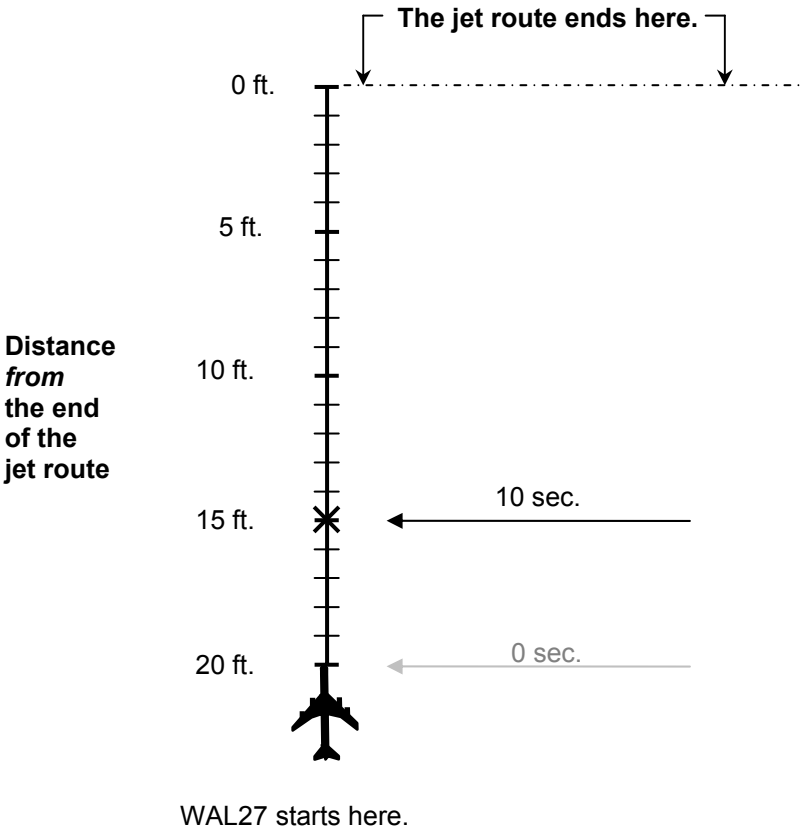
- □ After 30 seconds, Flight WAL27 has moved 5 feet closer to the end of the jet route. So the plane is 5 feet from the end of the jet route.
- □ Draw an **X** to show the position of Flight WAL27 after 30 seconds.
- □ At the **X**, draw an arrow marked "30 seconds."

- □ Keep going until the plane reaches the end of its jet route.

When you are done, answer this question.

How many seconds will it the plane to travel 20 feet to the end of the jet route? _____ seconds

Name


The jet route ends here.
0 ft.
5 ft.
10 ft.
15 ft.
20 ft.
Distance *from* the end of the jet route
10 sec.
0 sec.
WAL27 starts here.

Name

How Much Time To Reach the End of the Jet Route?

(Plot Points on a Grid to Find the Answer)

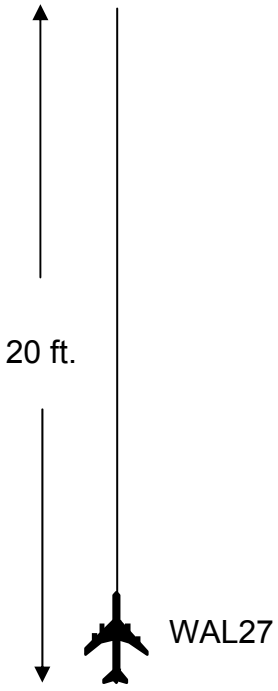
In the picture below, an airplane is flying on a jet route.

The World Airlines plane has flight number **WAL**27.

The speed of Flight WAL27 is 1/2 foot/second.

In 2 seconds, the airplane travels 1 foot.

In 10 seconds, the plane travels 5 feet.



Name _____

Flight WAL27 starts 20 feet from the end of the jet route.
After 10 seconds, the plane has traveled 5 feet.
So after **10** seconds, the plane is **15** feet ***from*** the end of the jet route.

On the given grid on page 3, we represent that information with the point (**10**, **-15**).
We use **negative** fifteen because the point lies **below** the horizontal line at 0 feet where the jet route ends.

The **X** at the point (10, -15) shows the position of Flight WAL27 after 10 seconds.

Now it's your turn to plot points on the given grid.

- □ After 20 seconds, Flight WAL27 has moved 5 feet closer to the end of the jet route. So the plane is 10 feet from the end of the jet route.
  On the grid, we represent that information with the point (20, -10).
- □ Put an **X** at the point that shows the position of Flight WAL27 after 20 seconds.

- □ After 30 seconds, Flight WAL27 has moved 5 feet closer to the end of the jet route. So the plane is 5 feet from the end of the jet route.
  On the grid, we represent that information with the point (30, -5).
- □ Put an **X** at the point that shows the position of Flight WAL27 after 30 seconds.

- □ Keep going until the plane reaches the horizontal line at 0 ft. where the jet route ends.

When you have finished plotting points, answer this question.

How many seconds will it take the plane to travel 20 feet
to the end of the jet route? _____ seconds

Name

Time traveled